Structural Analysis via Cellular Automata: Parameters of Wings of Boeing 737

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Abstract: The role of cellular automata is comprehensively within the genre of structural analysis as the compendium of areas is subdivided into sectional areas which are called cells. A cell contains characteristics or traits of the area being analyze where this area is bounded or contained in the cell. Individual cell is represented by differential equations that would govern the endeavours of the designated cell. The alteration of attributes of an individual cell would affect the traits of the neighbouring cells. This is the primary gist of cellular automata, the dependable entities of surrounding parameters. This paper delineates the advent of the usage of cellular automata in the procreation of analysis of a structure. The chosen structures are the wings (right and left) of Boeing 737. The wings are partitioned into cells and the methodologies of cellular automata as bestowed earlier are parlayed. Results of the analysis are compared with conventional data of the same genre (Boeing 737) which postulates and stipulates the deterministic nature of cellular automata. The variables (individual cells) that are dependable are measured in accordance with the rate of alteration of cells and the domino affect of it. These are tabulated and would give a comprehensive structural analysis.

1 Introduction

1.1 Cellular Automata

Cellular Automata is denoted as a system that comprises of cells where these cells would be in states or characteristics that could be defined. If one of the cells changes (in state or characteristic), the neighbouring cells adjacent to the “changed cell” would also change (Wolfram, S. 2004a). This effect is the entity that governs Cellular Automata, bestowing it a unique insignia or signature.

The state or characteristic (of a cell) is defined to be “alive” or “dead” (Wolfram, S. 2004b). This could also be represented by 1 or 0 where 1 denotes “alive” and 0 denotes “dead”. But other denotations of the state could also be actuated (which comprises not only “alive” or “dead” but other stipulations). With the usage of a more comprehensive denotation (of the state), binary notation is not used. Numerical notation is used instead.

Since changes occur to neighbouring cells, this adumbrate that if a cell at location “a” changes, another cell at location “b” (which is located at a point that is extremely distant from location “a”) would also change. This criterion bestows an avenue to analyze distant cell or point at distant location by applying the concept of Cellular Automata.

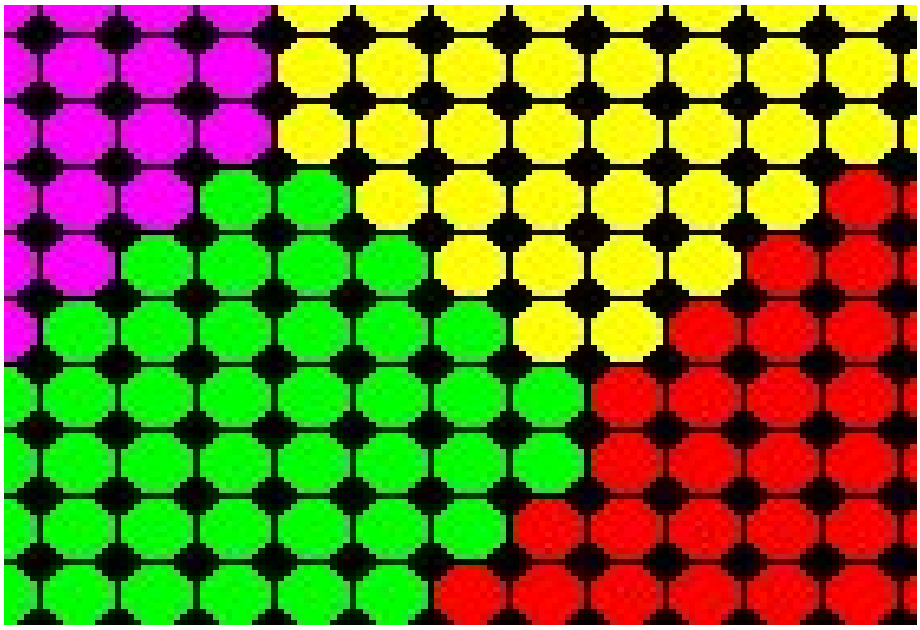

Figure 1. Cells are Represented by Colours and Circular Shapes

1.2 Subsets of Cellular Automata

There are variations of Cellular Automata where each variation would parlay almost similar results. These variations exist in lieu with the existence of myriad situations and each situation requires distinct methodology to garner results of high fidelity.

There are 5 variations of Cellular Automata. These variations are : Q-State Life, Belousov-Zhabotinsky Reaction, Togetherness, Viral Replication, and Diffusion-Limited Aggregation (Meyer, P. 2002a). Each offers solution based on their methodologies. But the gist remains the same : cells evolved during pre-designated time frame.

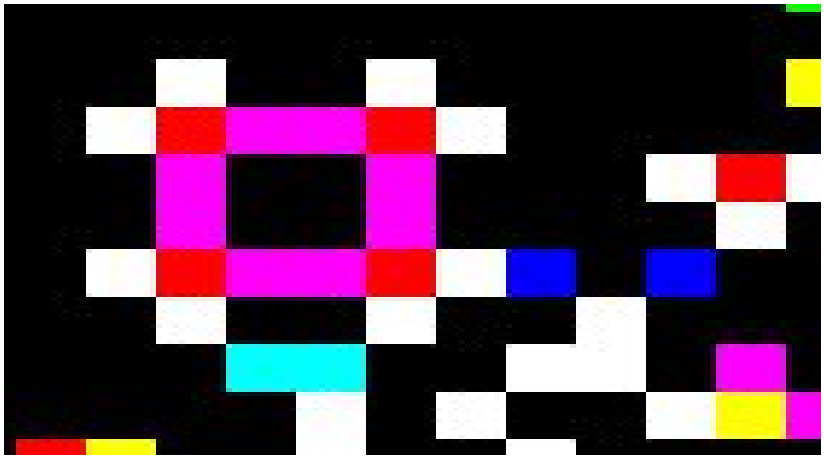

Figure 2. Evolution of Cells of Q-State Life

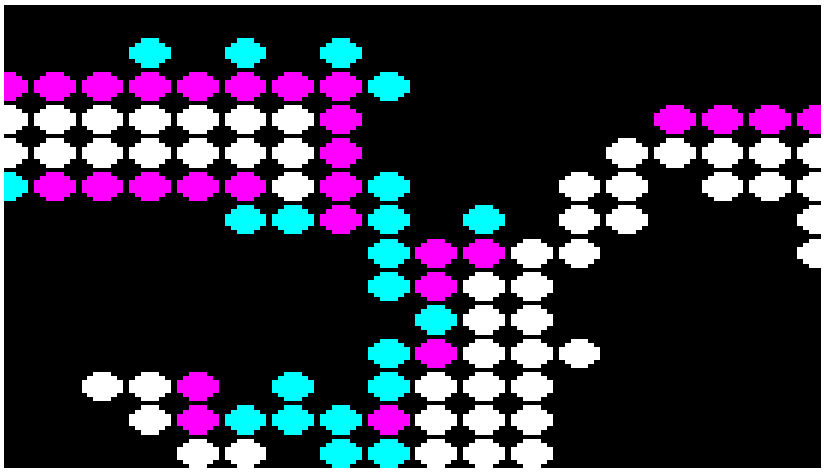

Figure 3. Evolution of Cells of Viral Replication

1.3 Intended Analyses

The intention is to procreate analyses upon the primary wings of Boeing 737-200 using doctrines of Cellular Automata. The main attribute of the research is to postulate the pattern of spreading of detrimental entity upon the primary wings of Boeing 727-200. Primary wings are discerned to be the left primary wing and the right primary wing.

2 The Applied Doctrines

2.1 Boeing 737-200 of Malaysian Institute of Aviation Technology

Universiti Kuala Lumpur Malaysian Institute of Aviation Technology (UniKL MIAT) is an institution that offers courses in Maintenance, Repair, and Overhaul (MRO) of Aircrafts (Universiti Kuala Lumpur 2003). The institution is equipped with several aircrafts notably the Boeing 737-200, located in the hangar of the institution.

Figure 4. Boeing 737-200 of Malaysian Institute of Aviation Technology

The Boeing 737-200 is currently grounded but the structure of the primary wings is intact and coherent, hence analyses of the primary wings if within acceptable norm. The wing span of the primary wings is 28.35m (93ft 0in) and the area is 91.1m^2 (980sq ft) (Chant, C. 1990).

There are peaks and valleys etched inherently on the surface of the primary wings. This physical situation would not pose a predicament as only 2 dimensional analyses are actuated, obliterating the need to measure depths and heights.

Figure 5. The Physical State of the Primary Wings

2.2 Q-State Life

Q-State Life stipulates the evolution of cells within designated time frame. It indicates the spreading of coloured cells (within the context of any colour defined by the user) among the other cells. For example : Cells which are red in colour spread among cells of various colours. The spreading is analogous to patterns where these could be observed. Predictions on the direction and concentration of spreading could be actuated.

In Q-State Life, a cell could be in state 1 or state 2 or state 3 or state 4 or state Q (Meyer, P. 2002b). Q is a numerical integer value that a user could denote. If Q equals to 11, then a cell could be in state 1 or state 2 or state 3 or state 4 or state 5 or state 6 or state 7 or state 8 or state 9 or state 10 or state 11. Each state is represented by a colour. Each colour represents “a state”. If a cell changes colour, this portrays a change in state. Let state 1 be represented by the colour blue and state 2 be represented by the colour pink. If a cell of colour blue changes it’s colour to pink, this process elucidates the change of state (of the cell) from state 1 to state 2.

The changes would occur in accordance with the algorithms and axioms of Q-State Life. “A step” is termed as “an occurrence” of the algorithms of Q-State Life. “2 steps” indicate “2 occurrences” of the algorithms. “3 steps” indicate “3 occurrences” of the algorithms. Each occurrence would dwell upon the cell or cells, thus evolving the cell or cells.

“A step” or “many steps” is/are deemed as time. As time increases, the cell or cells would evolve. There exists a state duly called the “dead state”. A “dead state” is a state where the cell or cells is/are deemed non-existent. The “dead state” is usually represented by the colour black. After several iterations of the algorithms of Q-State Life (“several” could be equated as one step or million steps), the propensity for all the cells to be obliterated exist.

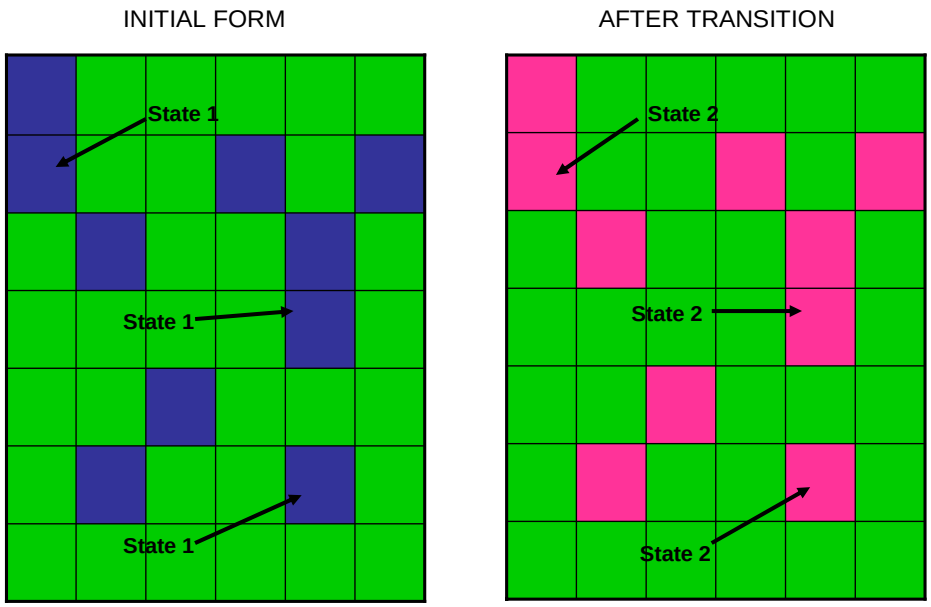

Figure 6. An Example of the Evolution of Cells

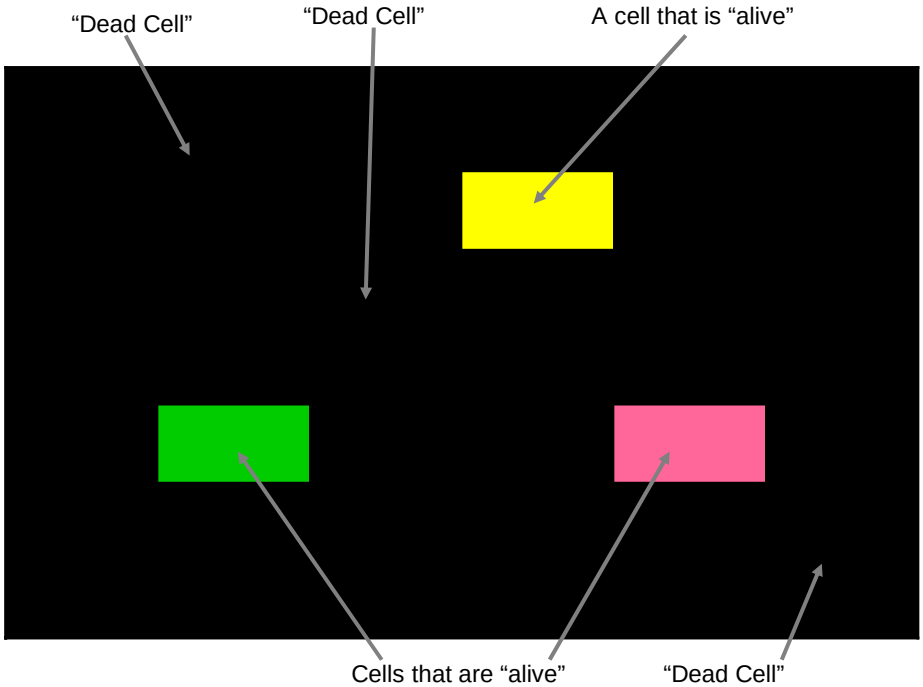

Figure 7. Combination of Cells that are Alive and Dead

2.3 Application of Q-State Life upon Primary Wings of Boeing 737-200

The right and left primary wings of Boeing 737-200 are symmetrical, thus analysis of one wing (right or left) is adequate. Analysis of the right primary wing would bestow results that are similar to the analysis of the left primary wing. The right primary wing was chosen to be the medium of contention.

The right primary wing is postulated to be in the form of a torus where there would not be boundaries upon the wing. The surface of the wing is continuous infinitely. The upper and lower surfaces of the wing are considered interconnected. These are the characteristics of a torus (Stewart, J. 1995).

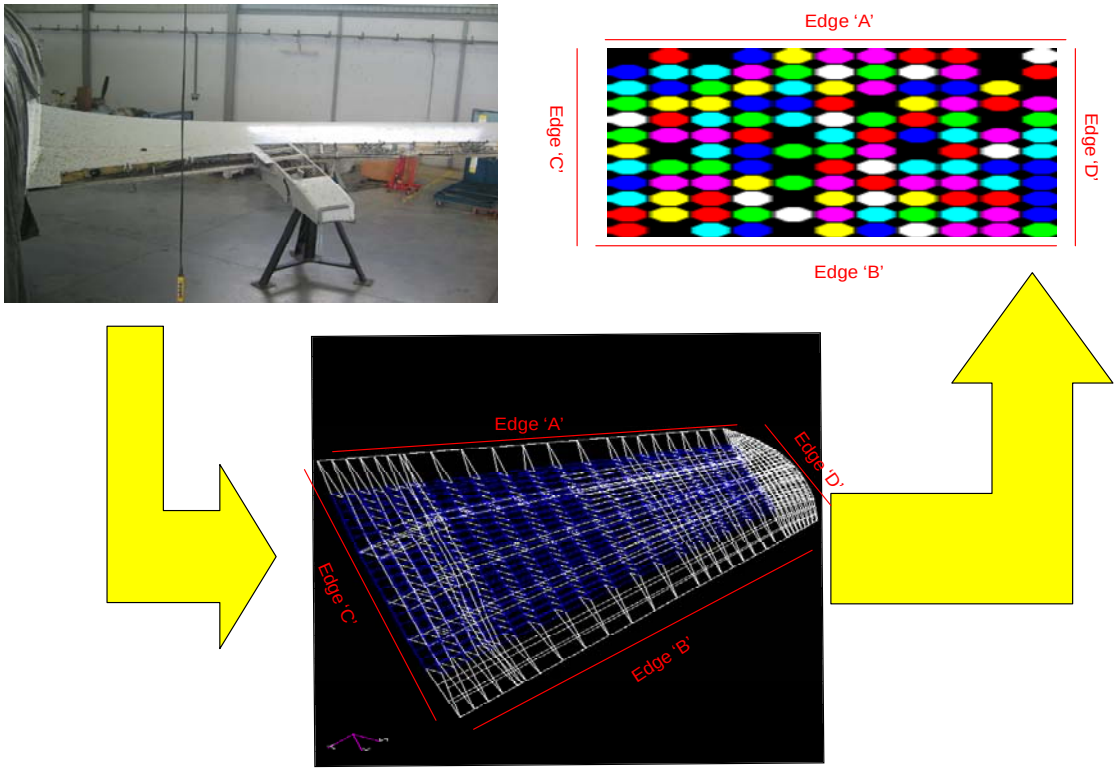

Figure 8. Transformation of the Wing into a Torus

As observed in Figure 8, the physical entities of the primary wing are transformed into a torus where Edge 'A' and Edge 'B' are interconnected to form a continuous apparition of cells (cells would appear to be infinitely continuous without any defined boundary). Similar traits are defined for Edge 'C' and Edge 'D'.

The cells are circular in nature and this would not give detrimental results if one is to compare circular cells with rectangular cells. The main agenda is to beget the "spreading process" (the spreading of cells that are black).

3 Results and Observations

3.1 Initial Apparition

For a torus, the "rule of thumb" for Q-State Life is to use 5 states. With the application of 5 states, optimum results are within reach. The default values for k1, k2, k3, and k4 are 16, 20, 16, and 17 respectively. Array size is discerned to be 66 (Meyer, P. 2002c). These values are inputted into the software "Five Cellular Automata 6.12". The initial situation is shown in Figure 9.

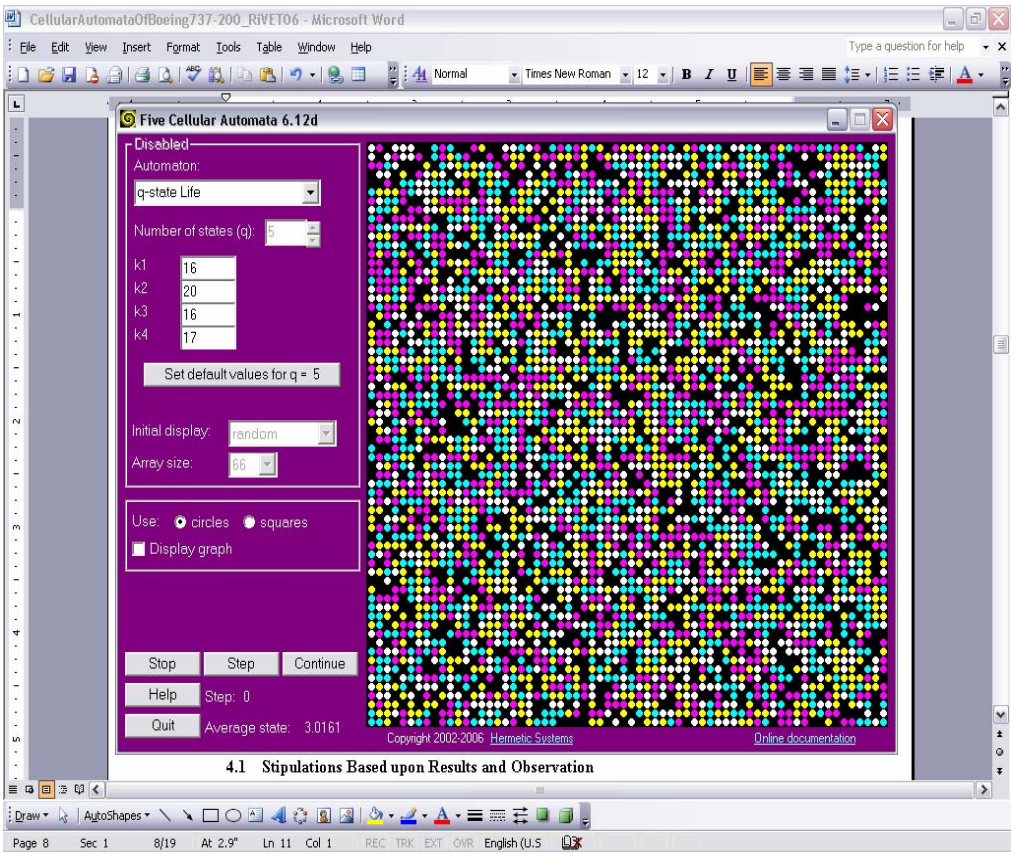

Figure 9. Initial Situation of the Cells

The initial situation emerges as a situation that is full of cells that are alive. During the transition stage, black cells begin to emerge. These black cells would fulfill the prophecy of being dominant.

3.2 Final Apparition

The final situation or apparition is shown in Figure 10.

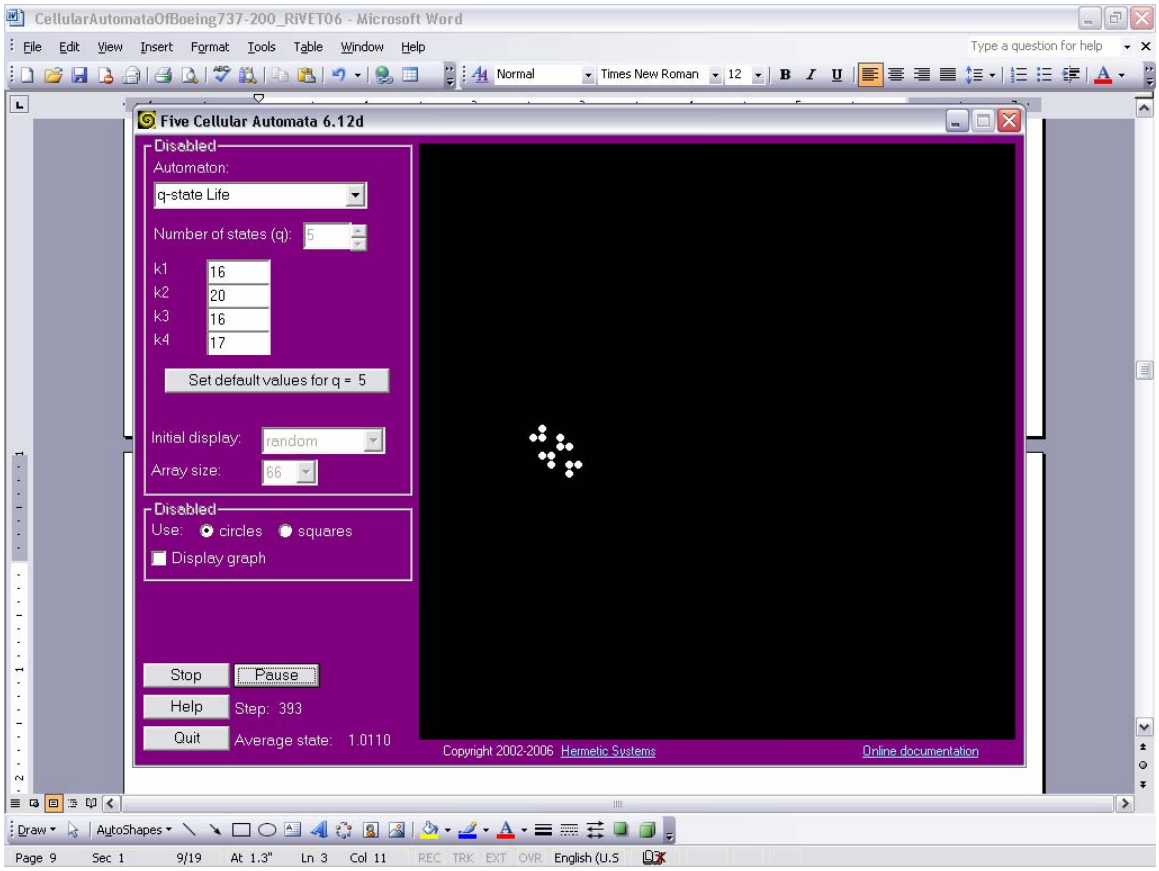

Figure 10. The Final Apparition of the Cells

The black cells dominate the entire area. Cells that are alive are minute in number. At Step 393 (time) the domination of "dead cells" is profoundly apparent. Further Steps (after 393) procreates similar apparition, thus the evolution of cells had stop at point Step 393.

3.3 Significant of Results

A black cell is analogous to detrimental temperature fluctuation. As indicated in the results, the spreading of black cells denotes the spreading of anomalies of temperature throughout the surface of the primary wings of Boeing 737-200. The areas that are not affected by these anomalies of temperature are the areas represented by the cells that are alive. It was observed that only a minute fraction of the area of the primary wing is unaffected by the abnormal temperature fluctuation.

4 Conclusions

4.1 Stipulations Based upon Results and Observation

Only a fraction of the area of the primary wings is considered concretely viable in terms of safety of structure. Areas which are prone to anomalies of temperature are considerably unsafe (plausibly minor). The tendency of spreading (of detrimental entity) is high and legitimate based upon data and pertinent facts. The alteration of the physical parameters of the wings could perhaps reduce the spreading of anomalies.

4.2 Usage of Cellular Automata

The usage of Cellular Automata has proven to be useful in lieu with analysis of behaviour of structures. The adherents to the methodologies of Cellular Automata had parlay results which are discretely prominent. The results act as 2 dimensional mediums (of graphical means) that aid scrutiny of structures.

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